O 77: Poster Session - 2D Materials: Stacking and Heterostructures

Time: Wednesday 18:15–20:00 Location: P2/EG

O 77.1 Wed 18:15 P2/EG

Electronic transport in graphene on monolayer hexagonal boron nitride on the local scale — •Benno Harling, Anna Sinterhauf, and Martin Wenderoth — IV. Physikalisches Institut, Universität Göttingen, Germany

The promising electronic transport properties of the first true two-dimensional material graphene are known to be strongly affected by interactions with the substrate below the graphene sheet. One method currently being considered to reduce this influence is the use of suitable dielectric substrates such as boron nitride.
Here, we use the AFM-based method of Kelvin probe force microscopy with additionally applied in-plane bias voltage [1] to investigate the local electronic transport properties of the commercially available van-der-Waals-system monolayer graphene on monolayer hexagonal boron nitride on SiO_2 under ambient conditions. Our measurements reveal a highly inhomogeneous transport behavior. We find a strongly locally varying potential gradient as well as local voltage drops. These local voltage drops depend on the direction of the current flow through the sample and on the current density. The asymmetric behavior of the device under current flow reversal is additionally observed in macroscopic measurements. Furthermore, we find a dependence of the sheet resistance on temperature and propose a model based on a resistor network consisting of ohmic resistors and diodes, with which it is possible to describe large parts of the experimental findings. Financial support by the DFG through project We 1889/13-1 is gratefully acknowledged.
[1] Willke et al., Carbon 102, 470-476 (2016)

O 77.2 Wed 18:15 P2/EG

Substrate dependent energy level alignment at a hybrid transition metal dichalcogenide monolayer/molecular semiconductor interface — •Jie Ma[1,2], Patrick Amesalem[1], Xiaomin Xu[3], Thorssten Schultz[1,2], Dongguen Shin[1,2], and Norbert Koch[1,2] — [1]Institut für Physik & IRIS Adlershof, Humboldt Universität zu Berlin, Germany — [2]Helmholtz Zentrum Berlin für Materialien und Energie GmbH, Germany — [3]Tsinghua-Berkeley Shenzhen Institute (TBSI), China

Combining transition metal dichalcogenides (TMDCs) and molecular semiconductors (MSCs) is an attractive route for forming van der Waals heterostructures[1] with novel (opto-)electronic properties. Such properties are expected to strongly depend on the energy level alignment at the corresponding interfaces, which may also be influenced by the employed supporting substrate[2]. In particular, a detailed microscopic understanding of the impact of the substrate electrical properties on the energy level alignment at TMDC/MSC interfaces is still lacking. Here, we determined by angle-resolved ultraviolet and X-ray photoelectron spectroscopy the electronic band line-up at a WS2/C60 interface supported by either an insulating or a semi-metallic substrate. These insights can be useful for future design of functional heterostructures with tailored (opto-)electronic properties based on the combination of 2D and molecular semiconductor materials.

[1] D. Jariwala. et al. Nano Lett. 16, 497-503 (2016).
[2] P. Soohyung. et al. Commun Phys. 2 (2019) 109.

O 77.3 Wed 18:15 P2/EG

Air tightness of hBN encapsulation and its impact on Raman spectroscopy of sensitive van der Waals materials — •Lorenz Bauriedl[1], Johannes Holler[1], Tobias Korn[2], Andrea Seitz[1], Furkan Özyigit[1], Michaela Eichinger[1], Christian Schüller[1], Kenjii Watanabe[3], Takashi Taniguchi[3], Christoph Strunk[1], and Nicola Paradiso[1] — [1]University of Regensburg — [2]University of Rostock — [3]National Institute for Materials Science, Tsukuba

In this work, we study the air-tightness of hBN encapsulation of devices based on sensitive 2D materials, as e.g. $NbSe_2$. hBN encapsulation is the most common passivation method for a wide range of 2D material-based devices. We use Raman spectroscopy to monitor the photo-oxidation induced by intense illumination as a function of time for several encapsulation layouts. We demonstrated that full encapsulation in hBN effectively provides a long term protection against oxidation for samples kept in ambient conditions. The same does not hold for half encapsulated devices, i.e. with hBN applied only on the top. In this latter case, we observe a slow but relentless diffusion of oxygen in between the hBN layer and the SiO_2 substrate.

O 77.4 Wed 18:15 P2/EG

Raman Spectroscopy of layered magnetic systems — •Mainak Palit, Anudeepa Ghosh, and Subhadeep Datta — School of Physical Sciences, Indian Association for the Cultivation of Science, Kolkata, India

Metal phosphorus trichalcogenides (MPX3) have emerged as an exciting class of layered magnetic 2D materials for future spintronics. Retaining long range magnetic ordering even in the exfoliated few layers is the hallmark of 2D magnetism. Raman spectroscopy can be an effective probe to identify low-energy phonon modes and possible spin-phonon coupling in reduced dimension from bulk crystal. In this study, temperature dependent Raman Spectra of exfoliated iron phosporous trichalcogenides (FePS3) flakes reveal a distinct shift of the large wave number phonon peaks towards higher wavenumber as temperarure decreases. A clear deviation from standard anharmonic behavior below characteristic Néel temperature (TN) is also observed. Other low wave number symmetry modes exhibit temperature dependent non-anharmonic self-energy as a function of layer thickness below TN, related to the strong spin-lattice interaction due to short-range magnetic order. Energies and symmetries of the observed Raman-active modes are in agreement with DFT calculations. Below TN low wave number broad mode in the paramagnetic state(T>TN) splits into multiple distinct modes and evolve further into a possible magnon mode. We believe these results will pave way for possible spintronic applications exploiting magnons.

O 77.5 Wed 18:15 P2/EG

Towards high mobility graphene field effect transistors with ultraclean exposed surface ensuring scanning probe compatibility — •Rosen Sofroniev, Yanting Liu, Tjorven Johnsen, Sayanti Samaddar, and Markus Morgenstern — II. Institute of Physics B, RWTH Aachen University and JARA-FIT, Otto-Blumenthal-Str., 52074 Aachen, Germany

Providing large, clean surfaces of gated graphene and other 2D materials is the key challenge for investigating them by Scanning tunnelling spectroscopy (STS). Most of the fabrication processes that have resulted in exceptionally high mobility devices yet, have targeted transport measurements such that the 2D material is encapsulated or the surface cleanliness is not ensured. In this work, we assemble boron nitride/graphene stacks with a graphite back-gate on SiO2/Si substrate, with all contacts realized prior to the graphene transfer i.e. we transfer the graphene as the last step over a centrally placed graphite (gate)/hBN stack and two neighbouring contacted graphite flakes on either side that would serve as source and drain electrode. The final PMMA based dry transfer, ensures clean surfaces free of any resist and the possibility of parallel probing by STS and electronic transport at low temperature. In future application, this technique would allow transfer of air sensitive 2D material inside argon glove boxes.

O 77.6 Wed 18:15 P2/EG

A setup for time-resolved second-harmonic imaging microscopy to study charge-transfer processes in 2D heterostructures at cryogenic temperature. — •Marleen Axt, Ulrich Höfer, and Gerson Mette — Fachbereich Physik, Philipps Universität Marburg, Germany

Two dimensional materials like transition metal dichalcogenides (TMDC) have attracted tremendous interest in designing optoelectronic devices. Of special interest are vertically stacked 2D Van-der-Waals heterostructures and their charge-transfer processes including the formation of strongly bonded interlayer excitons. However charge transfer at atomically sharp interfaces has been found to be extremely rapid, occuring on a femtosecond time scale and therefore is rarely observed.

Here, we present an experimental setup to study ultrafast charge-transfer dynamics at cryogenic temperatures with time-resolved second-harmonic imaging microscopy. Symmetry-based nonlinear optical properties of 2D materials are used to determine the crystallographic orientation of individual layers. Pump-probe experiments are performed using a new laser system providing ultrashort laser pulses (< 30 fs) with tunable energies for both, pump and probe laser pulses. With high temporal and spatial resolution we investigate TMDC-monolayers and heterostructures including temperature-dependent measurements for systematic studies.

O 77.7 Wed 18:15 P2/EG

Growth and Characterization of van-der-Waals heterostructures prepared from modulated elemental precursors — •Fabian Göhler[1], Erik C. Hadland[2], Marisa Choffel[2], Aalaa Osman[1], Constance Schmidt[1], Dietrich R.T. Zahn[1], Florian Speck[1], David C. Johnson[2], and Thomas Seyller[1] — [1]Chemitz University of Technology, 09126 Chemnitz, Germany — [2]University of Oregon, Eugene, OR 97403, United States

Modulated elemental reactants (MER) offer a new avenue to synthesize a virtually unlimited number of previously unknown heterostructures. In this two step synthesis, an amorphous precursor is first deposited by sequential physical vapor deposition. By precisely calibrating the thicknesses and layering sequence of the constituents to mimic the targeted structure, it is possible to crystallize the precursor into a layered thin film via annealing in inert atmosphere. Due to the structuring of the precursor on an atomic level, the necessary energy input as well as layer intermixing during crystallization is reduced, enabling the synthesis of metastable structures with arbitrary complexity. [1] Recently, we were able to push the MER synthesis towards the two-dimensional limit by preparing a one monolayer thick, nanocrystalline layer of $MoSe_2$ on a substrate of epitaxial graphene on SiC. [2] Building on these results, we are now exploring the incorporation of different types of bismuth selenide layers into the heterostructure to tune the electronic and structural properties of the $MoSe_2$.

[1] Westover et al., *J. Solid State Chem.* **236**, 173 (2016).
[2] Göhler et al., *Phys. Stat. Sol. B* **256**, 1800283 (2018).

O 77.8 Wed 18:15 P2/EG

Probing two-dimensional magnets with single spin magnetometer — •Qi-Chao Sun[1], Tiancheng Song[2], Rainer Stöhr[1], Xiaodong Xu[2], and Jörg Wrachtrup[1,3] — [1]3. Physikalisches Institut, Universität Stuttgart, Stuttgart 70569, Germany — [2]Department of Physics, University of Washington, Seattle, Washington 98195, USA — [3]Max Planck Institute for Solid State Research, Stuttgart 70569, Germany

The two-dimensional (2D) magnets, which show novel phenomena due to the reduced dimensionality, open up opportunities to understand the magnetic properties in materials as well as design new spintronic devices. Here, we report our recent measurement on the atomically thin chromium trihalides materials by using a cryogenic scanning magnetometer based on a single nitrogen-vacancy (NV) center in a diamond tip. By quantitatively measuring the stray magnetic field of the material, we reconstructed the magnetization with a spatial resolution of ~80 nm, which is consistent with the previously reported value. Moreover, the scanning NV magnetometer is also capable of detecting the AC magnetic field generated by spin fluctuation and spin-wave, paving a new way of studying the 2D magnets.